

CLAIMS

What is claimed is:

- ✓ 1. An optical waveguide formed on a substrate and comprising a waveguide core sandwiched between an upper cladding layer and a lower cladding layer, with the lower cladding layer being patterned to form a mesa structure having a width that varies with distance along at least a portion of the length of the optical waveguide, and with the thickness of the waveguide core varying in proportion to the width of the mesa structure.
2. The optical waveguide of Claim 1 wherein the waveguide core comprises a spin-coatable material selected from the group consisting of polymers, sol gels, and spin-on glasses.
3. The optical waveguide of Claim 1 wherein the thickness of the waveguide core varies substantially linearly with distance above the portion of the mesa structure wherein the width varies with distance.
4. The optical waveguide of Claim 2 wherein the upper and lower cladding layers each comprise spin-coatable materials which have indices of refraction that are different from an index of refraction of the waveguide core.
5. The optical waveguide of Claim 4 wherein the indices of refraction of the upper and lower cladding layers are larger than the index of refraction of the waveguide core.
6. The optical waveguide of Claim 1 further including a first silicon oxynitride etch-stop layer deposited over the mesa structure.
7. The optical waveguide of Claim 6 further including a second silicon oxynitride etch-stop layer deposited over the waveguide core.
8. The optical waveguide of Claim 1 wherein the width of the mesa structure varies nonlinearly with distance over the portion of the mesa structure wherein the width varies.
9. The optical waveguide of Claim 1 wherein the width of the mesa structure varies exponentially with distance over the portion of the mesa structure wherein the width varies.

10. The optical waveguide of Claim 1 wherein the upper cladding layer is patterned to provide a uniform width over a major part of the length thereof and a variable width over a minor part of the length thereof.
11. The optical waveguide of Claim 10 wherein the width of the upper cladding is uniformly tapered along the minor part of the length thereof, and the thickness of the waveguide core is fixed underneath the minor part of the length of the upper cladding wherein the width of the upper cladding is uniformly tapered.
12. The optical waveguide of Claim 1 wherein the substrate comprises silicon.
13. The optical waveguide of Claim 12 wherein the substrate further includes an insulating layer formed on an upper side of the substrate below the lower cladding layer.
14. The optical waveguide of Claim 13 wherein the insulating layer comprises a material selected from the group consisting of a thermal oxide, a low-pressure chemical-vapor-deposited material, or a plasma-enhanced chemical-vapor-deposited material.
15. The optical waveguide of Claim 1 wherein the waveguide core has a thickness in the range of 0.2 - 4 microns.
16. The optical waveguide of Claim 15 wherein the upper cladding layer has a width in the range of 1 micron to one centimeter.
17. The optical waveguide of Claim 16 wherein the mesa structure formed in the lower cladding layer has a width in the range of 5 - 250 microns.
18. The optical waveguide of Claim 17 wherein the portion of the mesa structure wherein the width varies with distance has a length in the range of 100 - 1000 microns.
19. An optical spot-size transformer comprising the optical waveguide of Claim 1.

- ✓ 20. An optical spot-size transformer for coupling light between an optical fiber and an optical waveguide formed on a substrate, comprising:
- (a) a first section of the optical waveguide located proximate to the optical fiber for altering a lateral dimension of an optical mode of the light, with the first section further comprising a waveguide core sandwiched between an upper cladding layer and a mesa structure formed in a lower cladding layer, with the waveguide core and the mesa structure both being substantially uniform in width and height, and with the upper cladding layer having a substantially uniform height and a nonuniform width that increases with distance away from the optical fiber; and
 - (b) a second section of the optical waveguide located distal to the optical fiber for altering a vertical dimension of the optical mode of the light, with the second section further comprising the waveguide core sandwiched between the upper cladding layer and the mesa structure, and with the height of the waveguide core and the width of the mesa structure both increasing with distance away from the optical fiber.
21. The optical spot-size transformer of Claim 20 wherein the optical fiber comprises a single-mode optical fiber.
22. The optical spot-size transformer of Claim 20 wherein the waveguide core comprises a spin-coatable material selected from the group consisting of polymers, sol gels, and spin-on glasses.
23. The optical spot-size transformer of Claim 22 wherein the upper and lower cladding layers comprise spin-coatable materials which have indices of refraction that are different from an index of refraction of the waveguide core.
24. The optical spot-size transformer of Claim 20 wherein the upper cladding layer has a minimum width in the range of 0.5 - 2 microns at an end thereof facing the optical fiber.
25. The optical spot-size transformer of Claim 20 wherein the width of the mesa structure in the second section of the optical waveguide increases nonlinearly with the distance away from the optical fiber.

26. The optical spot-size transformer of Claim 20 further including a substrate for supporting the optical waveguide.
27. The optical spot-size transformer of Claim 20 wherein the substrate comprises a material selected from the group consisting of semiconductors, glasses, fused silica, sapphire, metals, metal alloys, ceramics, polymers, resins, and printed wiring boards.
- ✓ 28. A method for forming a vertically-tapered optical waveguide on a substrate, comprising steps for:
- (a) forming a lower cladding layer on the substrate, and patterning the lower cladding layer to form a mesa structure having a mesa width that varies with distance along at least a part of the length of the optical waveguide;
 - (b) forming a waveguide core on the mesa structure by depositing a spin-coatable material over the mesa structure with a thickness of the waveguide core at any point along the length of the optical waveguide being defined by the width of the mesa structure at that point; and
 - (c) forming an upper cladding layer above the waveguide core.
29. The method of Claim 28 wherein the step for depositing the spin-coatable material comprises rotating the substrate; spinning on the spin-coatable material over the substrate; and removing the spin-coatable material from the substrate at locations beyond the mesa structure.
30. The method of Claim 29 further comprising a step for forming a first silicon oxynitride etch-stop layer over the mesa structure prior to the step for forming the waveguide core.
31. The method of Claim 30 further comprising a step for forming a second silicon oxynitride etch-stop layer over the waveguide core prior to the step for forming the upper cladding layer.